TITLE OF PRESENTATION: PRIORITISING SAFETY INVESTMENT THROUGH COMPARATIVE RISK ASSESSMENT
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PRIORITISING SAFETY INVESTMENT THROUGH COMPARATIVE RISK ASSESSMENT

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SUMMARY

In 1998 a Government commissioned independent review of railway safety addressed, inter alia, the safety adequacy of the Irish railway system. In conducting the review consultants International Risk Management Services (IRMS) developed a model that calculated the level of individual and cumulative risk exposure on various sections of the network. This information was used to support prioritisation of expenditure of 660m n.p.v. under the first five year phase of an envisaged fifteen year Government funded railway safety investment programme commencing in 1999. A more refined model has since been developed built on a wider and more extensively populated asset database and including rolling stock and human factor inputs.

In addition to providing a more robust basis for prioritising investment over the second five year phase of the safety investment programme the underlying process of risk assessment is a key element of the operational safety management system. Where there are no mandated standards, or elements of the system that are operated under grandfather rights do not comply with best industry practice, it also provides an effective mechanism for demonstrating safety adequacy.

BACKGROUND

Irish railway system

The Irish mainline railway system is vertically integrated and is managed and operated by Iarnród Éireann (IE) which is a wholly state owned company. The network extends to approximately 1900 route kilometres principally comprising radial routes centred on Dublin. 25% is double track and in excess of 90% of train movements are under either full automatic train protection or continuous automatic warning systems. Services are predominantly passenger based with an average daily ridership of 100,000, approximately ⅓ on inter-city services and ⅔ on suburban rail [1] .

1997 Passenger train derailment

On the 8th of November 1997 all seven carriages of a passenger train travelling between Dublin and Sligo derailed. The accident occurred in a cutting and though the body-shells of the rear four carriages of the consist, which comprised British Rail MK III type stock, maintained their structural integrity there was significant running gear damage and the track in this area was completely destroyed. The train divided and the locomotive and three leading carriages, which came to rest a further 400m along the line, were only partially derailed. Though the damage to the train and track was significant there were only minor injuries to 3 of the 180 passengers.

The accident occurred in a cutting which contained the derailment, but had it occurred a short distance further down the line on embanked track the outcome could have been significantly worse. It raised serious concerns regarding infrastructural safety and prompted Government to commission an independent strategic safety review of the railway system and its operation and also of its own railway safety regulatory framework.

1998 REVIEW OF RAILWAY SAFETY

Remit and methodology

A consortium of consultants led by IRMS conducted the review and reported in October 1998 [2]. Their remit required that they address the adequacy of IE's

- safety policy, systems rules and procedures including methodologies of assessment of safety risk and prioritisation of related expenditure,
- on-the ground implementation of rules and procedures and
- infrastructure including track, signalling, rolling stock and level crossings.

It was also required that the consultants, in the context of the system and its operation, use their professional judgement to define 'unreasonable risk' and identify any that existed at the time of the review or was likely to arise in the subsequent five to ten years and require remedial action within that timeframe.

Building on established industry practice IRMS defined upper and lower annual fatality and equivalent fatality risk tolerability limits for passengers, employees and other members of the public within and ALARP (*As Low As Reasonably Practicable*) framework. Similarly, using national and international data, figures for the value of preventing fatality (VPF) were derived for a situation where the railway had the prime duty of care, where the victim had significant control over the situation or where the fatality or injury occurred in the course of an illegal act on the part of the victim such as malicious trespass.

System risk model

To facilitate their process of assessing network safety IRMS prepared a risk model. The railway network was divided into 37 discrete sections for each of which the major infrastructural assets such as track and signalling were quantified and condition rated. Along with train speed, frequency and passenger numbers this comprised the model input data. For each network section the model predicted annual accident frequency, collective passenger, train crew and public risk exposure, and individual passenger risk exposure.

Model output and review findings and recommendations

There was no section of railway where the risk was found to be intolerable. The most striking finding however was that, contrary to common belief within the railway, the highest risk was not on the lightly used lines where arguably the worst track and signalling conditions occurred but, because of high train frequency and passenger numbers, on the Dublin suburban rail system.

IRMS found that

- large sections of the system infrastructure were in poor condition and that major improvements were needed in the short (immediate) medium (0-5 years) and long (5-10 years) term and also recommended that
- a new mandate be prepared for the railway inspectorate within an updated safety regulatory framework.

SAFETY REGULATORY FRAMEWORK

The provisions of the new safety regulatory framework, contained in the Railway Safety Bill 2001 [7] (RSB 2001), are structured around the concept of responsibility for management of risk residing with the creator of that risk, that is, the duty holder. Rather than working to centrally prescribed standards the undertaking itself decides on the most appropriate means of managing risk with the safety regulator simply providing guidance on how this might be achieved.

The adoption of such an approach was primarily a reflection of its being seen as having worked effectively in other industries such as oil and nuclear and in other railways. It was also however a pragmatic choice in that, other than requirements mandated in historical legislation [8], Ireland has no national railway standards and the resources needed to draft an extensive suite of such standards and codes of practice would, for a small State, have been wholly disproportionate in the context of the size of the industry.

At the core of such frameworks is the requirement for the duty holder to prepare a safety case that demonstrates to the safety regulator the adequacy of its safety management systems. To do this the duty holder must, in any particular aspect of operations, either

- comply with relevant mandated standards,
- have adopted best industry practice or
- have conducted a robust assessment that shows that associated risk is tolerable.

In revoking the historical legislation containing national industry requirements the RSB 2001 adopts a wholly hands-off approach in relation to standards and codes of practice. While the safety regulator has prepared draft guidance on Safety Case content [9] and on the Design and Construction of Railway Infrastructure and Rolling Stock [10] both are high level requiring the duty holder to adopt and analytical approach to the process of safety validation rather than simply follow a predefined roadmap.

RAILWAY SAFETY INVESTMENT

Government Task Force

Taking on board the IRMS recommendations Government established a task force with representation from IE, and from the government Departments with responsibility for Transport and for Finance, to agree the allocation of 660m n.p.v. expenditure over the first 5 years of what was envisaged would be a 15 year safety investment programme.

While some elements of the programme also yielded operational benefits, in all instances the primary justification for expenditure was the need to improve safety. In so far as was practicable the programme was structured to ensure that at any one time all strands of expenditure delivered the same value for money in terms of risk mitigation. To achieve this the programme broadly reflected the IRMS findings and recommendations prioritised on the basis of the infrastructure risk model output. The model did not however take into account level crossing safety which, in common with most railways, represents one of the highest areas of operational risk on the IE system.

Level crossing risk assessment

In 1998 there were approximately 2000 level crossings on the IE system including those that were public or private, automated or manually operated and attended or unattended. In 1997 IE engaged consultants Arthur D Little (ADL) to risk assess all of its level crossings [11] . As with the IRMS review the assessment ranked risk at each level crossing within an ALARP framework for which upper and lower tolerability limits had been established.

Since however there was no linkage between the level crossing risk assessment and the safety model, while the data from this risk assessment was used to prioritise funding within the safety investment programme allocated to improving level crossing safety, it was not possible to correlate this expenditure with that allocated to the improvement of other infrastructure elements.

In agreeing the 1999-2004 expenditure programme [12] the Task Force required [13] that over the period of that programme the risk model be developed to enable all aspects of railway risk, including that relating to human factors, could be effectively compared.

In addition to the initial review of railway safety IRMS were also required to carry out two follow up implementation audits [14] [15] during which the model was re-run incorporating data updated on the basis of the investment programme. On each occasion there were reductions in risk on a number of parts of the system evidencing the tangible safety benefits of the programme.

COMPREHENSIVE SYSTEM RISK MODEL

Development

As safety duty holder, ownership the model transferred to IE, who engaged Environmental Rick Management (ERM) to construct a trial holistic risk model for a small section of railway that encompassed all the key elements of the wider network. Having proved concept IE, assisted by consultants Sotera, then expanded the model to cover the whole network. This work involved;

- a comprehensive process of asset assessment using Hazid and FMECA (*Failure Modes Effects and Criticality Analysis*) to condition rate a fully populated asset register including level crossings and rolling stock
- assessing the robustness of safety management systems including policy, organisation, planning, implementation and review
- an overview of human performance taking into account the safety criticality of roles, task analyses and management system rating.

A process of peer review ensured, in so far as was practicable, consistency in associated risk assessment workshops.

Scale

To fully run the model, which is Excel based supported by Fault Tree +, takes between 2 and 3 weeks and in developing it over 250 hazard and risk workshops were held. In comparison with the 37 system elements in the original model a total of 227 functional locations were used and 15,300 separate assets assessed including track, bridges and structures, level crossings, signals, points and crossings, track circuits and rolling stock.

Scope

The model included,

- risk to passengers, staff, contractors and members of the public from
- equipment failure, operational errors such as SPADs (*Signals Passed at Danger)*, maintenance error, third party acts such as vandalism, weather and the environment on
- the operational railway, in depots, workshops and sidings and on adjacent property affected by the railway.

Excluded were,

- suicide,
- occupational Health and Safety Issues in offices,
- environmental harm from the operational railway

- failures that have an exclusively operability impact
- long term occupational health issues and
- incidents on roads and pavements on the approach to railway premises

Results

For equivalent elements of the system the model predicted increased risk compared with the output of the 1998 model. This was not however unexpected given the inclusion of data on level crossings and rolling stock where there were known to be safety shortcomings. On two specific lines the risk was found to be intolerable necessitating immediate mitigating that was achieved by replacing life expired passenger carriages with new diesel multiple units. Similarly the risk to shunters was found to be intolerable though in this instance mitigation measures were already being implemented.

The relatively small size of the IE system means that from most accident and incident types data sets are statistically insignificant and at best ongoing safety performance can only be judged against multi annual trend lines. The model therefore is largely predictive rather than reflecting actual measured on the ground risk. Where however comparison was possible it was found that predicted risk tended to be higher than actual risk. This again was not unexpected since the process of risk assessment tends to be pessimistic rather than optimistic. It would be expected however that as the model if further refined and calibrated there will be convergence between predicted and actual risk.

Discounting increased ridership and life cycle asset deterioration the model predicts that over the period 2004-2009 safety investment in physical assets will reduce risk by 40% equating to 2.7 equivalent fatalities. Inclusion of predicted benefit from investment in soft safety systems is expected to show a further reduction in this figure over the same period.

CONCLUSIONS

A comprehensive risk model provides a robust basis for the prioritisation of safety investment across all operational railway systems and, through the adoption of risk tolerability thresholds and value of preventing fatality criteria, a basis for the justification of that expenditure. On an ongoing basis it also provides means for assessing the safety return on that investment.

Within a safety case based regulatory framework it is also a valuable analytical tool for helping the duty holder understand where the greatest operational risks lie. The associated process of risk assessment is also an integral part of the duty holder’s collective safety management systems in which context it both assists the duty holder in the process of demonstrating safety adequacy and the safety regulator in the process of approval.

In the final analysis the robustness of the process of safety validation, including both duty holder and safety regulator systems, will be tested within the national judicial framework. The presence of a comprehensive risk model based of a rigorous process of risk assessment provides both parties with a firm basis on which to demonstrate effective stewardship of their respective responsibilities.

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